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UNITED STATES DEPARTMENT OF AGRICULTURE

DEPARTMENT BULLETIN No. 1172

Washington, D. C. ▼ August, 1923

CEREAL EXPERIMENTS AT CHICO, CALIFORNIA

By

VICTOR H. FLORELL

Assistant Agronomist, Office of Cereal Investigations
Bureau of Plant Industry

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INTRODUCTION.

Experiments with cereals under dry-land conditions in the Sacramento Valley have been conducted since 1910 at the Plant Introduction Station, Chico, Calif., in cooperation with the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry. At the end of the crop season of 1921 the investigations were transferred to the University Farm, Davis, Calif., where they will be conducted in cooperation with the California Agricultural Experiment Station. The results obtained at Chico in the principal lines of experimentation during this period are presented in this bulletin. The more important lines of investigation have been varietal experiments with wheat, barley, and oats and breeding and classification studies with wheat.

Chico is located in the northern third of the Sacramento Valley, about 100 miles north of Sacramento, and its soil and climate are fairly representative of conditions which prevail over most of the district.

THE SACRAMENTO VALLEY.

The Sacramento Valley lies in the middle of the north-central part of California. (Fig. 1.) It parallels approximately the eastern and western boundaries of the State and extends from Redding in the north, where the Sacramento River emerges from the Sacramento Canyon, to the union of the Sacramento and San Joaquin Rivers in the south. It is traversed longitudinally by the Sacramento River and is inclosed by the Sierra Nevada Mountains on the east and the Coast Range on the west.

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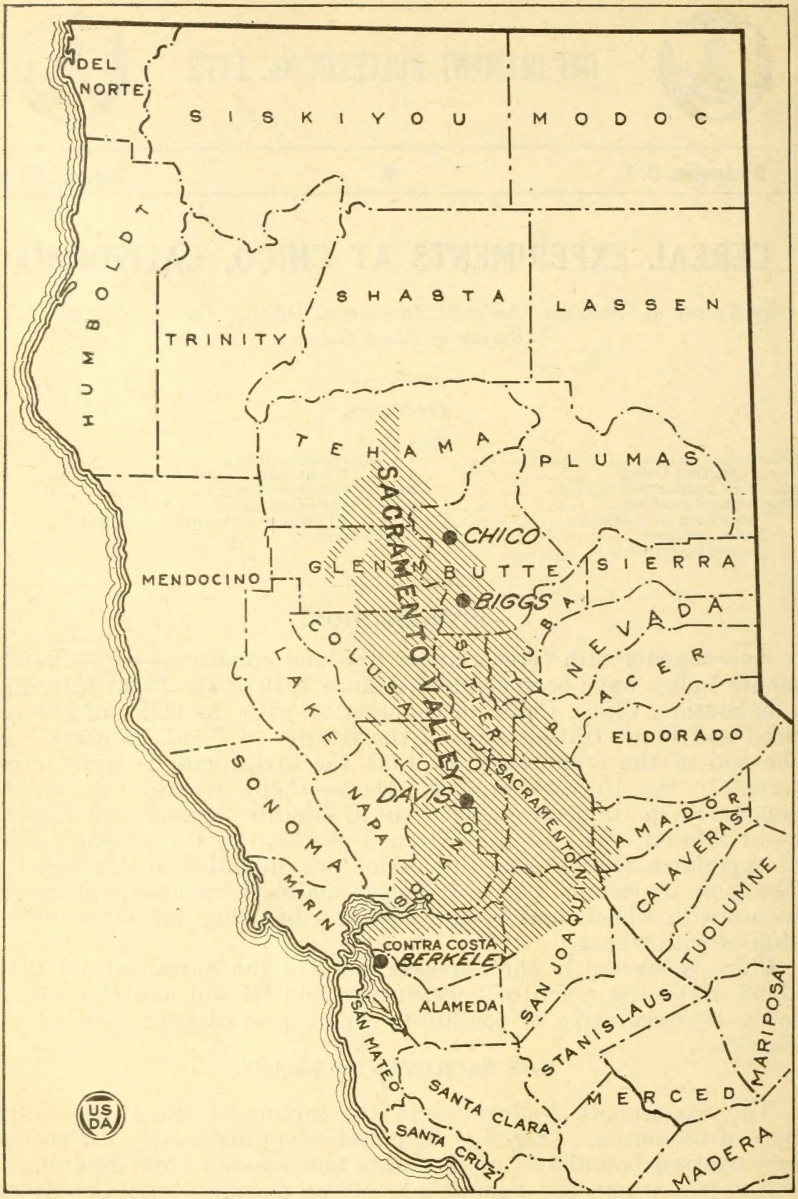

FIG. 1.—Sketch map of the northern half of California, showing the location of the Sacramento Valley and of the Plant Introduction Station at Chico, the Rice Field Station at Biggs, the California University Farm at Davis, and the California Agricultural Experiment Station at Berkeley.

TOPOGRAPHY.

The valley lies in a troughlike depression which is believed once to have been an arm of the sea and which later was filled to its present level by material transported by the streams from the inclosing mountain ranges. The result is a broad, flat valley, varying in width from only a few miles in the extreme north to about 40 miles at Sacramento. The wide portion of the valley begins a short distance north of Chico. The altitude of the valley floor[1] ranges from a few feet above sea level at its mouth to about 500 feet in the north, with the Sierras on the east rising to elevations of 6,000 to 8,000 feet and the Coast Range on the west to elevations of 2,000 feet in the south to 6,000 feet in the north.

For the most part, the valley floor is quite level, although in several sections it is gently rolling to somewhat hilly. South of Chico the lands along certain portions of the Sacramento River are higher than those more distant from the river, due to the deposition of sediment during times of flood.

SOIL.

Many varieties of soil are found in the Sacramento Valley. While most of these are of sedimentary origin, a few are residual and yet others of miscellaneous origin. The alluvial soils comprise the most fertile and most highly developed lands of the valley. While there are large areas of these lands they are often interspersed by undifferentiated soil types. The alluvial soils usually are about 6 feet deep,[1] although both deeper and shallower strata occur. These soil types are underlain by undifferentiated material of varying structure. The adobe or clay soils, which are very heavy in character, comprise another large group, of which there are several large areas as well as numerous smaller ones. These soils usually are from 2 to 3 feet deep and generally are underlain by a clay or hardpan subsoil. The lighter, shallower soil types usually are found toward the outer edges of the valley and on the gentle foothill slopes.

CLIMATE.

Climatic conditions in the Sacramento Valley are marked by two distinct seasons. The wet, or rainy, season occurs in winter and the dry, or rainless, season in summer.

In general, the rainfall increases gradually from south to north, though there are some exceptions, as noted later. It ranges from about 15 inches annually in the southern portion of the valley to 25 inches at Red Bluff on the northern border. The greater part of this precipitation falls in the four coldest months, while the summer months are practically rainless. Snow rarely occurs except in the extreme northern portion, where it usually melts within a few hours, or at the most in a few days, after it falls. Thunderstorms and hailstorms rarely occur. Rainstorms usually are gentle in character, although heavy rains sometimes occur. A rainstorm generally lasts two or three days. During especially wet seasons they may last for a week to 10 days.

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[1] Holmes, L. C., Nelson, J. W., et al. Reconnaissance Soil Survey of the Sacramento Valley, California, U. S. Dept. Agr., Bur. Soils, Advance Sheets, Field Oper., 1913, 148 p., 1 fig., 3 pl., map. 1915.

Precipitation is lighter in the middle of the valley than at the margins on either side. On the east side of the Sacramento River the precipitation increases from south to north, but on the west side it decreases slowly to the northward as far as Williams and then increases again toward the north.

Summer in the Sacramento Valley is marked by a long period of high temperatures by day. These, however, are moderated by comparatively low night temperatures. The difference between day and night temperatures averages about 40° F. The maximum temperature at Red Bluff in summer in a 33-year period was 114° F., while the maximum at Sacramento in summer in a 62-year period was 110° F. Sea breezes from San Francisco Bay moderate the temperatures in the south. The winters, on the other hand, are mild with no low temperatures. At Red Bluff in the period stated the minimum was 18° F., and at Sacramento in the 62-year period it was 19° F. Usually only thin films of ice form in winter during the occasional cold periods.

In general, the Sacramento Valley is an area of comparatively low wind movement. However, at certain seasons of the year moderately strong winds frequently occur. The prevailing winds are from the south and are strongest in the middle of the valley and at its south end. In spring and early summer north winds are not infrequent. Strong drying winds of three or more days duration, locally known as "northers," are not uncommon and frequently become destructive by reducing the moisture supply in growing grain or other crops or by shattering ripened grain.

In the winter or rainy season the humidity is high and evaporation low; during the cloudless days of spring and summer the reverse conditions obtain and evaporation is correspondingly high. Evaporation is greatly increased during a "norther."

CEREAL PRODUCTION.

The principal dry-land cereals grown in California are wheat and barley. The industry began about 1850 and reached its maximum about 1880, when California was one of the leading wheat-producing States in the Union. Since that date the more fertile grain lands have been devoted to fruit growing, and the acreage and production of cereals have decreased steadily except for a few years during and after the World War, when high prices greatly stimulated wheat production. Barley also has largely displaced wheat on the lighter lands, so that now it is a more important crop than wheat.

TABLE 1.—*Comparison of acreage and production of wheat, barley, and oats in the Sacramento Valley and in the State of California in the year 1919.*

Crop.	Area grown.			Production.		
	In the valley.	In the State.	Part of total.	In the valley.	In the State.	Part of total.
	Acres.	*Acres.*	*Per cent.*	*Bushels.*	*Bushels.*	*Per cent.*
Wheat	385,816	1,086,428	35.5	6,611,868	16,866,882	39.2
Barley	339,927	987,068	34.4	8,381,245	21,897,283	38.3
Oats	49,376	146,889	33.6	788,857	2,966,776	26.6

Table 1 shows the acreage and production of wheat, barley, and oats in the Sacramento Valley and in the entire State in the year 1919, and the percentage of each crop produced in the valley. Although the production of wheat was abnormally large in that year, the relative production in the Sacramento Valley and in the State then and at the present time should be about the same.

WEEDS.

Most of the weeds of economic importance infesting grain fields in the Sacramento Valley have been introduced. Only two or three of them are native. Those responsible for causing the greatest injury to grain production include wild oats (*Avena fatua* and *Avena barbata*), star thistle (*Centaurea solstitialis*), Napa thistle (*Centaurea melitensis*), wild mustard (*Brassica nigra*), buckthorn (*Amsinckia intermedia*), bur clover (*Medicago hispida*), and morning-glory (*Convolvulus arvensis*). Those of lesser importance are cheat (*Bromus hordeaceus*), broncho grass (*Bromus villosus*), canary grass (*Phalaris* spp.), wild radish (*Raphanus sativus* and *R. raphanistrum*), filaree (*Erodium* spp.), California poppy (*Eschscholtzia crocea*), and a number of others.

The wild oat flourishes on all types of soil and probably causes more reduction in grain yields than any other weed. It grows naturally on practically all uncultivated land in the Sacramento Valley. It is used extensively for hay and is not considered objectionable except on cultivated land. It is hard to eradicate because in most seasons the seeds when plowed under remain dormant in the soil during the average dry season and are thus carried over to grow another year. When a wet season occurs, an abundance of wild oat appears, and such a season is known by farmers as an "oat year." The wild oat is not considered particularly objectionable as a weed in grainfields so far as producing mixed grain is concerned, as it nearly always matures and shatters out before the grain is harvested. It greatly reduces yields, however, if abundant, and grainfields badly infested with wild oat usually are cut for hay.

The star thistle is found on the lower lands and where it gains a foothold is very destructive. It begins to develop rapidly about the time the grain ripens and frequently interferes seriously with harvesting operations. Napa thistle grows on a greater variety of soils but is not so destructive as the former. Wild mustard, wild radish, buckthorn, broncho grass, and the California poppy usually are found on the loam soils, while bur clover, cheat, and canary grass are most abundant on the heavy wet soils. Morning-glory once established is difficult to control and most often is found on the richer soils. Of those listed only the California poppy, buckthorn, and a few of the canary grasses are native.

CEREAL DISEASES.

The principal cereal disease of economic importance in the Sacramento Valley is bunt, or stinking smut. Seed treatment is a necessary precautionary measure. Stem-rust infection usually is very light. In some seasons, however, it causes severe damage on the low lands along the Sacramento River. Light infections of yellow rust or stripe rust usually may be seen on susceptible varieties.

THE PLANT INTRODUCTION STATION.

The Plant Introduction Station comprises approximately 210 acres of land located about 4 miles southeast of Chico at the edge of the valley floor and about 1 mile from the foothills of the Sierra Nevada Mountains. Its altitude is approximately 189 feet. It is traversed from east to west by a dry stream bed, which is bordered by a fringe of woods consisting principally of valley oak. This channel, which is used to conduct irrigation water from Butte Creek, a perpetual stream lying to the southeast of the station, is believed to have been at one time the old bed of that stream. With the exception of a small area extending into the foothill slopes, the topography of the station is quite level, with good drainage.

SOIL.

The soil is an alluvial silt loam. The type, which is known as Vina loam, comprises some of the most fertile lands of the valley. When farther removed from the foothills, this soil is usually 6 or more feet in depth and usually underlain by gravel. At the Plant Introduction Station the soil varies from the maximum depth to very shallow and is underlain by gravel or various undifferentiated soil materials. In general, it may be described as consisting of irregular bodies of deep soil interspersed with shallower areas and shallow spots, with an occasional gravel outcrop. The nonuniform condition has been a very disturbing factor in comparative experiments with cereals. The poorer spots manifest themselves principally in shorter, lighter straw and reduced yields. Many of the discrepancies in recorded data are due to this condition.

CLIMATE.

The climate at Chico is similar to that of other places in this portion of the valley. Its precipitation is somewhat greater than in places farther south or more nearly in the middle of the valley. Wind velocities also are lower than farther out in the valley or toward its southern end. The average temperatures usually are several degrees higher than at places in the southern extremity of the area.

Precipitation.

The average monthly, seasonal, and annual precipitation at Chico in the 51-year period[3] from 1871 to 1921, inclusive, is shown in Table 2. The average annual precipitation for the period was 23.69 inches, and the average seasonal precipitation (September to May) was 23.24 inches, which is but 0.45 of an inch less than the annual. The season from September to May includes the time when the first fall rains come to the end of growth and maturity of cereal crops. When sufficient rain falls in September, plowing for grain is begun and the summer fallow prepared for seeding during that month. With no early rains, plowing is delayed until rain falls, although the preparation of a seed bed on summer fallow may proceed.

[3] United States Department of Agriculture. Weather Bureau. Summaries of Climatological Data. Section 15—Northeastern California [1871–1910]. U. S. Dept. Agr., Weather Bur., Bul. W, v. 1, sect. 15. 1912.
United States Department of Agriculture. Weather Bureau. Climatological Data, California Section. v. 1–25. 1897–1921.

June, July, August, and frequently also September are practically rainless. Table 2 shows the number of times each month was rainless during the 51-year period from 1871 to 1921.

TABLE 2.—*Average monthly, seasonal, and annual precipitation and number of times each month was rainless at Chico, Calif., during the 51-year period from 1871 to 1921.*

Character of data.	Month.												Seasonal (Sept. to May).	Annual.
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.		
Precipitation:														
Average	5.00	3.79	3.22	1.58	1.00	0.39	0.04	0.02	0.60	1.18	2.67	4.20	23.24	23.69
Times rainless	0	1	0	5	8	25	46	42	21	11	3	1	.....	.....

Table 3 shows the monthly, annual, and seasonal precipitation, with averages and maxima and minima in the 12-year period from 1910 to 1921, inclusive. The average annual precipitation was 24.62 inches and the seasonal 24.61 inches in the 11 years, which are approximately 1 inch greater than the corresponding averages for the 51-year period. Frequently very heavy monthly rainfall is recorded during the wet season. In 1911, 1914, and 1916 the January rainfall was 11.39, 10.51, and 12.48 inches, respectively, and in November, 1920, it was 10.68 inches. All but one of these seasons of excessive monthly rainfall have been reflected in reduced yields. On adobe lands during such seasons there is much drowning of grain, owing to poor soil drainage and standing water.

TABLE 3.—*Monthly, annual, and seasonal precipitation at Chico, Calif., in the 12-year period from 1910 to 1921, inclusive.*

[Precipitation data in inches. T=trace. The seasonal averages are for the period from September to May, inclusive, for the 11 years shown.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.	Seasonal.
1910	3.77	2.49	3.62	0.23	0.06	0.05	0	0	0.71	0.50	0.86	1.77	14.06	.....
1911	11.39	2.04	5.86	1.43	.17	.20	0	0	.12	.31	.10	2.01	23.63	24.73
1912	3.27	.69	3.70	2.14	1.80	.12	T	0	4.84	1.23	3.14	1.02	21.95	14.14
1913	4.53	.82	2.41	1.16	1.39	1.01	.09	0	0	0	7.27	9.42	28.10	20.54
1914	10.51	6.27	.57	1.83	.36	1.87	0	0	0	.88	.53	5.55	28.37	36.23
1915	9.15	10.33	2.14	.93	3.22	0	0	0	T	.02	1.85	6.85	34.49	32.73
1916	12.48	3.28	1.91	.27	1.45	.80	.53	0	.40	2.10	2.09	4.94	29.85	28.11
1917	3.18	4.75	1.28	1.97	2.64	0	0	.10	.34	0	1.58	1.77	17.61	23.35
1918	1.01	4.74	5.41	.90	.70	T	0	T	3.49	.88	2.48	1.82	21.43	16.45
1919	3.38	7.36	3.37	.78	.10	0	0	0	.90	.36	.77	4.72	21.74	23.66
1920	.47	2.86	5.06	1.87	T	.09	T	.07	0	1.90	10.68	7.67	30.68	17.01
1921	7.91	1.84	2.24	.53	.94	T	0	0	.03	.96	2.69	6.43	23.57	33.71
Average	5.92	3.96	3.13	1.17	1.07	.35	.05	.014	.90	.76	2.84	4.50	24.62	24.61
Maximum	12.48	10.33	5.86	2.14	3.22	1.87	.53	.10	4.84	2.10	10.68	9.42	34.49	36.23
Minimum	.47	.69	.57	.23	T	0	0	0	0	0	.10	1.02	14.06	14.14

Temperature.

Mean, maximum, and minimum temperatures at Chico from 1910 to 1921 are shown in Table 4. The period of growth and ripening of cereals extends from about the middle of March to early in June. Temperatures usually remain cool through April and part of May, but late in May they generally rise rapidly, causing grain to ripen quickly. Midseason varieties of wheat and barley usually ripen in 6 to 8 days, and early varieties in 10 to 12 days. Unusually high

temperatures accompanied by a "norther" sometimes ripen grain in from 3 to 5 days. The highest mean and also the extreme temperatures occur in June, July, and August. During the 12-year period the maximum temperature recorded was 112° F., and the minimum was 13° F.

Table 5 contains the average monthly and annual mean temperatures in the 46-year period, 1871 to 1916, inclusive, and the monthly maximum and minimum temperatures in a 38-year period.

TABLE 4.—*Mean, maximum, and minimum temperatures at Chico, Calif., by months, for the 12-year period from 1910 to 1921, inclusive.*

[Data in degrees F.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean:													
1910	43.1	47.9	57.0	61.0	68.8	72.6	80.2	77.2	70.1	64.8	53.4	48.0	62.0
1911	46.4	45.8	55.7	56.8	61.4	74.0	79.4	74.8	66.6	62.0	52.8	45.2	60.1
1912	47.2	51.4	50.8	54.2	64.3	72.9	78.0	76.2	69.4	59.1	51.4	45.7	60.0
1913	42.3	48.9	51.1	57.4	66.2	72.5	82.2	74.8	74.8	65.7	52.4	44.4	61.4
1914	47.8	49.6	58.0	59.2	66.8	71.5	77.7	77.2	69.6	60.8	54.2	43.2	61.3
1915	43.7	49.6	57.2	59.0	61.6	73.6	79.4	79.2	71.2	65.2	52.4	44.6	61.4
1916	43.0	53.1	56.2	61.4	63.6	71.4	75.6	75.9	71.1	59.0	48.4	43.8	59.4
1917	42.1	49.5	49.2	56.4	61.6	74.0	82.0	79.2	72.0	68.0	53.4	58.6	62.2
1918	46.2	47.5	52.0	57.6	63.8	79.2	76.6	76.4	69.9	62.8	49.8	43.5	60.4
1919	45.8	47.7	50.8	59.9	69.2	72.4	79.2	76.7	70.6	59.0	51.3	43.5	60.5
1920	46.7	50.8	50.5	57.5	62.8	72.6	75.6	78.0	70.2	58.3	50.3	45.6	59.9
1921	45.1	51.4	54.5	57.4	63.2	75.2	78.5	73.9	70.0	64.3	53.4	47.5	61.2
Average	45.0	49.4	53.6	58.2	64.4	73.5	78.5	77.2	70.5	62.4	51.9	46.1	60.5
Maximum:													
1910	63	63	80	92	104	109	110	106	99	94	76	71	.....
1911	74	65	83	85	93	102	110	102	93	92	82	70	.....
1912	64	74	76	76	98	111	110	106	94	88	70	72	.....
1913	69	74	79	86	100	98	109	112	106	98	72	60	.....
1914	64	70	90	82	99	110	109	106	98	92	80	64	.....
1915	62	68	84	86	92	102	110	110	96	94	78	60	.....
1916	58	76	86	85	90	103	102	105	100	82	73	62	.....
1917	63	79	79	86	87	105	111	107	102	102	82	69	.....
1918	72	67	81	90	93	112	106	110	98	89	84	65	.....
1919	67	63	78	86	105	109	110	112	104	91	83	63	.....
1920	77	82	76	89	100	108	105	111	101	87	72	61	.....
1921	57	73	77	91	92	108	109	105	100	92	81	64	.....
Average	65.8	71.2	80.8	86.2	96.1	106.4	108.4	107.7	99.3	91.8	77.8	65.1	.....
Minimum:													
1910	18	21	34	37	33	40	48	50	40	40	28	26	.....
1911	25	23	34	30	36	49	46	50	42	38	26	22	.....
1912	24	24	28	34	38	48	52	48	45	34	31	22	.....
1913	13	22	28	31	40	45	50	50	45	40	28	26	.....
1914	26	26	36	34	42	46	52	48	44	36	26	24	.....
1915	22	30	34	38	40	50	50	52	44	38	28	22	.....
1916	28	31	27	33	39	45	53	43	45	35	20	18	.....
1917	18	22	26	28	34	45	52	51	42	36	32	29	.....
1918	25	28	26	29	41	46	50	51	47	35	24	22	.....
1919	19	29	29	32	43	42	47	45	45	27	27	20	.....
1920	28	28	31	32	37	46	50	52	42	33	29	30	.....
1921	25	27	34	28	34	44	50	47	43	38	22	29	.....
Average	22.6	25.9	30.6	32.2	38.1	45.5	50.0	48.9	43.7	35.8	26.8	24.2	.....

TABLE 5.—*Average monthly and annual mean temperatures at Chico, Calif., during the 46-year period from 1871 to 1916, inclusive.*

[Data in degrees F. The average monthly maximum and minimum temperatures shown are for a 38-year period.]

Kind.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Mean	46.9	50.3	55.6	61.6	68.4	77.1	83.9	81.5	74.6	64.4	53.8	47.5	63.8
Maximum	78	84	90	97	107	114	117	116	109	103	88	78	117
Minimum	13	20	25	30	33	40	46	48	40	34	21	22	13

Wind.

Wind velocities at Chico are exceptionally low. No wind data are available for Chico, but those recorded at the Biggs Rice Field Station, Biggs, Calif., during the eight-year period from 1914 to 1921 show that the maximum wind velocity seldom exceeds 12 miles per hour, while the average hourly velocity ranges from 2.4 miles in October to 4.2 miles in March.[a] The Biggs Rice Field Station is located about 20 miles south of Chico, in more open country, but the conditions at the two points are very similar.

Evaporation.

Evaporation data from a free water surface were recorded at the Biggs Rice Field Station, Biggs, Calif., for the seven months from April to October, inclusive, in the eight-year period from 1914 to 1921, inclusive.[a] The amount of evaporation at this station closely approximates what would be likely to occur at Chico, although the presence of irrigation water in the rice fields throughout the summer at Biggs probably results in reduced evaporation. The data show the highest rate of evaporation to be in June and July, when the average daily evaporation was 0.29 inch. The average total evaporation during the seven months was 45.36 inches.

One of the most important factors conducive to this large evaporation is the great number of clear sunny days. Table 6 shows the annual and average number of clear, partly clear, and cloudy days at Chico in the 12-year period from 1910 to 1921, inclusive. The heavy draft on soil moisture by growing crops and evaporation during the long dry season leaves the soil dry and hard and well depleted of soil moisture.

TABLE 6.—*Annual and average number of clear, partly clear, and cloudy days at Chico, Calif., in the 12-year period from 1910 to 1921, inclusive.*

Year.	Number of days.			Prevailing wind.	Year.	Number of days.			Prevailing wind.
	Clear.	Partly cloudy.	Cloudy.			Clear.	Partly cloudy.	Cloudy.	
1910	252	27	86	South.	1917	245	63	57	Southeast.
1911	259	26	80	Do.	1918	224	83	58	Do.
1912	218	32	116	Do.	1919	257	53	55	Do.
1913	235	21	109	Do.	1920	239	76	51	
1914	240	24	101	Do.	1921	234	58	73	
1915	234	29	102	Do.					
1916	217	65	84	Southeast.	Average.	237.8	46.4	81	

EXPERIMENTAL METHODS.

PREPARATION OF THE LAND.

The customary method of soil preparation for a crop of grain is to summer-fallow or to plow as early as possible after the first fall rains. The proper time to plow is early in spring, usually the latter part of March or April, when weeds and other vegetation may be turned under and the soil is in proper condition for plowing. Tillage to keep down weeds usually is not required during the dry summer

[a] Jones, Jenkin W. Rice Experiments at the Biggs Rice Field Station in California. U. S. Dept. Agr. Bul. 1155, 60 p., 15. fig. 1923.

season. In the fall the land ordinarily is double-disked and harrowed a short time before seeding.

At the Plant Introduction Station most of the plat experiments have been conducted on fall-plowed land. Owing to the limited area it has not been possible to follow a systematic rotation. In 7 of the 12 years the cereal experiments followed corn. The summer irrigation of this crop did not greatly affect soil-moisture conditions in the fall, as the moisture was fairly well exhausted by the growing crop and by rapid evaporation. Where the cereals followed corn, the land was plowed in the fall, usually in October or November. For the 1920 crop the corn stubble was dry-worked in October and November. In 1910 the cereals were grown on land fall-sown to wheat, which was plowed under in December; in 1911 and 1917 they followed alfalfa and in 1913 chick-peas. In 1921 they were sown on summer-fallowed land which was double-disked and harrowed before seeding. Most of the cereal nurseries have been grown on summer fallow or on cultivated areas previously used for tree nurseries.

PLAT EXPERIMENTS.

Two general methods of conducting experiments with cereals have been used. Up to 1916 the varieties were grown in single plats both with and without check plats. During this early period the plats used varied in size. In 1916 the replication of plats was begun but without check plats. From three to five replications have been used, but four has been the most common number. The 1/50-acre unit was used in most cases.

NURSERY EXPERIMENTS.

Nursery experiments have comprised a large part of the cereal investigations at Chico. Up to and including 1914 a limited amount of this work was done, consisting principally of varietal comparisons with wheat, barley, and oats. In 1915 the first wheat-classification nursery was grown, and in the following year a wheat-hybrid nursery was added. In 1918 large numbers of pure-line head selections of wheat and barley were grown, and in 1920 the dormancy experiment with barley and the date-of-seeding experiments with wheat, barley, oats, and flax were begun.

Table 7 lists the different kinds of material of each cereal which were grown and the number of individuals of each with the approximate number of rows (including replications) grown annually.

The nursery experiments may be divided into two general classes, comparative experiments and miscellaneous experiments. The comparative experiments have included comparisons of varieties, pure-line selections, and dates of seeding.

In the comparative experiments the rows were sown 1 foot apart and of varying length. During the early years the row was either 1, 2, or 8 rods long for all cereals. During the later years the length of the row depended upon the cereal used. For wheat it was 16 feet; for barley, 20 feet; for oats, 15 feet; and for flax, 17 feet. These lengths were chosen so that the following simple rule could be applied in calculating yields in bushels per acre when they were recorded in grams per row: For wheat, barley, and flax multiply the yield in grams by one-tenth or move the decimal point one place to the left. For oats, multiply by two and point off one place to the left.

TABLE 7.—*Number of varieties and strains and approximate total number of rows grown annually in the various nursery experiments at the Plant Introduction Station, Chico, Calif., in the 12-year period from 1910 to 1921, inclusive.*

Crop and experiment.	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
Wheat:												
Varietal experiments	100	134	59	.....	63	25	81	144	232	226	297	42
Pure-line selections	.....	.....	.....	77	.....	23	.....	.....	170	158	149	22
Increase for seed renewal	.....	.....	.....	.....	.....	.....	.....	104	.....	.....	.....	.....
Hybrids	18	.....	.....	.....	.....	.....	509	230	733	1,000	1,680	1,922
Classification nursery	.....	.....	.....	.....	.....	146	790	902	957	721	1,421	309
Barley:												
Varietal experiments	70	79	.....	90	20	93	242	266	181	210	208	27
Pure-line selections	.....	.....	70	104	.....	30	28	28	389	361	361	45
Hybrids and classification material	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	341
Dormancy experiments	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	154	121
Oats:												
Varietal experiments	19	20	.....	.....	15	.....	.....	.....	8	40	40	11
Pure-line selections	.....	.....	35	33	.....	.....	.....	.....	.....	.....	.....	.....
Flax:												
Varietal experiments	.....	.....	.....	.....	23	16	61	30	20	20	20	.....
Miscellaneous (emmer, spelt, etc.):												
Varietal experiments	2	.....	.....	4	14	.....	.....	6	4	4	4	.....
Date-of-seeding:												
Wheat, barley, oats, and flax	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	234	478
Approximate total, including replications	210	230	165	350	135	330	1,680	2,400	3,000	4,600	5,400	4,000

A uniform weighed quantity of seed was used for seeding each row, which was sown by hand until 1918, and since that year with a nursery drill. Up to and including 1918 varieties or selections were grown mostly in single rows. Since that date they have been grown mostly in triplicate, though sometimes with five replications. Agronomic notes have been taken on emergence, heading, ripening, and yield of grain and also on cereal diseases.

The rows were harvested by hand, and the barleys were bagged to prevent loss through shattering after harvest. Other cereals were bagged in some years. The threshing was done by a specially constructed thresher. The weight of grain has been recorded in both ounces and grams.

The miscellaneous experiments included wheat breeding, wheat classification, and a dormancy experiment with barley. These experiments have been sown mostly in 5-foot rows 1 foot apart, but wider spacing and longer rows have been used at times. Head selections or bulk seed have been sown, according to the plan of the experiment. The seed was spaced or sown in drills by hand or with a nursery drill. Where the grain was desired, the rows were hand-harvested, bagged where necessary, and threshed with a small cylinder thresher.

It is neither desirable nor possible to present in this bulletin all the data recorded in the nursery experiments. However, a brief statement of the general results of the experiments with each cereal will be given.

EXPERIMENTAL DATA.

The object in conducting cereal experiments at Chico has been primarily (1) to determine what varieties of the different cereals are best adapted to the upper Sacramento Valley and (2) to improve by

selection and breeding the cereals most commonly grown. While a certain amount of work has been done with the less important cereals to determine their adaptation, most attention has been given to wheat and barley, which are best adapted to the section and widely grown there. The cultivation of oats is limited, particularly on account of the high temperatures in early summer.

In determining their adaptation the varieties have been grown in field plats so as to approach field conditions as nearly as possible. The plat unit at Chico has varied, but the size used has been uniform in each year. The measure of adaptability has been the yield of grain taken in connection with the qualities desired in the cereal in question. In addition to determining yield careful observations have been made during the periods of growth and ripening on the habit of growth, susceptibility to disease, etc. Although an effort is made to approach field conditions it is recognized that from such small units

FIG. 2.—Wheat varieties in shock in the plat experiments at the Plant Introduction Station, Chico, Calif., in 1911.

the yields are somewhat above normal. This, however, does not affect the results sought in the experiment, as all varieties are grown under like conditions and are affected similarly.

Varietal experiments have been conducted also in the nursery, where large numbers of varieties from many sources have been grown. From time to time a number of the most promising of these have been advanced to the plats for comparative study.

WHEAT EXPERIMENTS.

Wheat will continue to be one of the principal grain crops of California. While increased areas of the more fertile lands are being converted into orchards, there will yet remain large areas of land which will be primarily adapted to grain growing. The cool wet winter season together with the warm early spring temperatures of the great interior valleys of California is favorable for the production of the class of wheat known as the soft white wheats. Varieties of

this class have been grown in this region since the beginning of the industry. They were originally introduced from Australia, where the climate is very similar to that of portions of California.

The soft white wheats are comparatively low in crude-protein content and high in starch. Their bread-making qualities, however, are fairly good. Repeated efforts have been made by growers and experimenters to introduce the superior high-grade hard red milling wheats from the central and northern United States, but without much success. The climatic conditions immediately result in inferior quality and usually in lower production than from the commonly grown white varieties.

In the varietal experiment the effort has been to discover wheats of better quality and higher yields for California. The varieties showing greatest promise in this direction are the hard white wheats of Australian origin. Where productiveness and general adaptability are approximately the same, quality as determined by milling and baking experiments has been the deciding factor in favor of a variety in the experiment. The interpretation of results is based on the varied data recorded and also on observations of varietal behavior and the effects of soil variation.

TABLE 8.— *Yields of 45 varieties of wheat and the average yield of each expressed as a percentage of the yield of White Australian, as grown at the Plant Introduction Station, Chico, Calif., during some or all of the years in the 12-year period from 1910 to 1921, inclusive.*

Class, group, and variety.	C. I. No.[1]	Yield per acre (bushels).												Percentage of yield of White Australian.
		1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	Average.	
COMMON WHEATS.															
Soft white spring:															
Pacific Bluestem (White Australian)	3019	28.0	[2]65.5	[2]31.5	[2]44.7	[2]34.7	[3]18.6	32.0	43.9	22.6	32.1	[2]45.0	18.0	34.7	100.0
Pacific Bluestem	2985	.....	.....	22.5	46.8	35.7	23.2	29.7	41.2	.....	.....	.....	.....	.....	.....
Do	4067	.....	.....	.....	.....	.....	.....	.....	45.0	21.1	35.2	45.0	16.7	.....	[4]98.7
Washington No. 362	4327	.....	.....	.....	.....	33.0	18.0	20.1	46.7	.....	.....	.....	.....	.....	91.2
Silver King	2990	.....	.....	30.0	43.5	32.5	26.2	28.5	.....	.....	.....	.....	.....	.....	99.5
Hudson Purple-straw	2991	.....	.....	30.0	43.2	30.0	21.0	29.3	.....	.....	.....	.....	.....	.....	95.0
Farmers' Friend	2992	.....	.....	32.5	43.3	28.0	18.7	21.0	.....	.....	.....	.....	.....	.....	88.9
Elephant	2824	.....	.....	31.2	.....	31.5	18.0	.....	.....	.....	.....	.....	.....	.....	95.2
Soft white winter:															
Prohibition	4038	.....	.....	.....	.....	.....	.....	.....	.....	17.5	.....	.....	.....	.....	77.4
Semihard white spring:															
Baart	1697	39.3	90.6	27.5	45.7	30.2	19.3	27.5	47.8	19.7	22.9	39.6	17.4	35.6	102.6
Propo	1970	27.0	86.0	33.7	45.5	29.0	18.2	29.7	45.0	20.7	35.0	35.0	.....	.....	101.6
Allora	1698	36.2	67.6	30.0	40.2	32.0	17.0	28.8	.....	.....	.....	.....	.....	.....	98.7
Oudebaard	6228	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	44.6	19.6	.....	101.9
Surprise (California Gem)	2986	.....	.....	30.0	44.0	32.0	22.0	26.0	41.6	19.7	31.9	.....	.....	.....	95.0
Dicklow	3663	.....	.....	.....	.....	.....	.....	.....	46.7	30.7	31.3	41.3	.....	.....	104.5
Galgalos	2398	27.0	63.3	28.5	43.3	23.2	.....	18.0	39.4	25.1	22.1	.....	.....	.....	86.5
Sonora	1743	32.0	57.3	.....	.....	27.7	.....	.....	.....	.....	.....	.....	.....	.....	91.3
Do	3622	.....	.....	.....	.....	33.7	22.2	25.9	34.3	18.7	24.2	.....	19.0	.....	88.2
Federation	4734	.....	.....	.....	.....	.....	.....	.....	.....	.....	38.8	51.2	17.3	.....	112.8
Canberra	4986	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16.7	.....	92.8

[1] Cereal Investigations accession number.
[2] Average of two check plats in 1911 and 1915, six in 1912 and 1914, and seven in 1915.
[3] Pacific Bluestem (C. I. No. 4067) substituted.
[4] Pacific Bluestem (C. I. Nos. 2985 and 4067) combined.

TABLE 8.—*Yields of 45 varieties of wheat and the average yield of each expressed as a percentage of the yield of White Australian, as grown at the Plant Introduction Station, Chico, Calif., during some or all of the years in the 12-year period from 1910 to 1921, inclusive*—Continued.

Class, group, and variety	C. I. No.	Yield per acre (bushels).													Percentage of yield of White Australian.
		1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	Average.	
COMMON WHEATS—con.															
Hard white spring:															
Talimka	2227–1	26.0	85.6	31.2	46.8	38.0	24.2	24.2							108.2
Do	2495								40.5	28.4	29.6				100.0
Hard Federation	4980									45.1	34.4	42.9			
Do	4733										36.7	40.9	13.8		[5] 115.9
White Federation	4981									50.0	36.7	44.6	12.2		121.9
Bunyip	5125												13.3		73.9
Bobs	2826									16.8	28.8				83.4
Hard red spring:															
Chul	2227–2	30.3	88.0	36.2	47.8	35.7	27.7	21.5	36.6	20.6	34.6				107.2
Fretes	1596	26.7		25.0	46.3										94.1
Do	1596–1		73.3			35.2	18.5	20.8	43.9			29.6			[6] 92.8
Do	1596–2		78.6			32.5	19.7	26.3							104.2
Koola	2203–4			35.0	49.0										110.2
Do	2203–2								39.9	30.6	31.5				103.4
Aroussi	2511–2		51.6	40.0	54.1	37.6	19.2	20.2	29.8	12.5					90.3
Marquis	4158								36.2	30.5	31.0	30.0	16.4		89.0
Hard red winter:															
Crimean	1437		57.6			17.2									74.7
Kharkof	2208		55.3	28.7											86.6
Do	1442								37.1	25.0	25.4		12.5		85.8
Turkey	1558		56.3			15.0									71.2
Soft red winter:															
Illini Chief											24.6				76.6
CLUB WHEATS.															
White winter:															
Hybrid 128	4326					16.2	23.2	23.4	47.8	30.3	32.7	39.6			93.1
White spring:															
Hybrid 143	4160					32.7									94.2
Little Club	4066								50.1	32.8	27.5	35.9	16.1		100.5
Red spring:															
Hybrid 123	4325					34.0	24.0	24.3	43.3	28.8	34.6				102.7
Unnamed	3018–R					26.7	19.5	24.2	47.8	24.1	32.1	40.4			93.8
DURUM WHEATS.															
Kubanka	2246	19.7	36.3												59.9
Yellow Gharnovka	2096	9.6	36.6			26.2									56.5
Marouani	1593	10.7	34.6												48.4
Kubanka	1440	8.5	29.6		29.5				34.7	24.5	27.9	28.8			65.1
Do	2221	2.5	32.3												37.2
Unnamed	1595			21.3		21.3									64.4
Arnautka	1494			25.0	32.3	19.0									68.8
Cavarna	2575			30.0	29.7										78.3
Velvet Don	2227	20.0	33.3												57.0
Unnamed	2235–2				34.8	27.7									78.7
POULARD WHEAT.															
Titanic	5535									21.8	19.8	20.4			62.2

[5] Hard Federation (C. I. No. 4980) and Hard Federation (C. I. No. 4733) combined.
[6] Fretes (C. I. Nos. 1596 and 1596-1) combined.

Varietal Comparisons.

PLAT EXPERIMENTS.

A large number of varieties of wheat from various sources have been compared in the plat experiments at the Plant Introduction Station. (Fig. 2.) Table 8 shows the annual yields of 45 varieties of common wheat, 5 of club wheat, 10 of durum wheat, and 1 of poulard wheat grown during some years in the 12-year period from

1910 to 1921, inclusive, with the average yields of Pacific Bluestem (White Australian) and Baart (Early Baart) for the entire period and the average yields of other varieties in terms of percentage of the yield of the White Australian strain of Pacific Bluestem in the years when both were grown. This wheat was chosen as a basis for comparison because it is the leading commercial variety of the section.

The average annual yield of Pacific Bluestem (White Australian) wheat for the 12-year period, 1910 to 1921, inclusive, was 34.7 bushels per acre and that of Baart 35.6 bushels. This shows a difference of 0.9 bushel per acre in favor of Baart. In view of the soil variation the yield of Baart should be discounted when the abnormal yield of 90.6 bushels from that variety in 1911 is considered. In considering quality as well as yield the most promising varieties have been White Federation, Hard Federation (Fig. 3), and Federation, which produced 121.9, 115.9, and 112.8 per cent, respectively, of the yield of Pacific Bluestem in the same years.

The following varieties of wheat (listed with their respective C. I. numbers), the results from which are not presented in Table 8, were also grown in plats for one or more years: Japanese No. 4, 1181–1; Kurd, 2126–2; Yantagbay, 2404; Kisel, 2405; Ble Violet, 2508–1; Ble Violet, 2508–2; Ak, 2899; Indian, 4506; Jumbuck, 4608; Bobs, 4710; Comeback, 4991; Firbank, 5013; Boadicea, 6220; Onas, 6221.

Other varieties among the white-kerneled wheats which show equal or higher yields than the best strain of Pacific Bluestem are Talimka, Baart, Propo, Oudebaard, which are bearded, and Little Club, a beardless club; among the hard red spring varieties are Chul, Koola, and Fretes, which are bearded, and the red club wheat Hybrid 123, which is beardless. Of these wheats Baart and Little Club are important commercial varieties in the Sacramento Valley. Chul was at one time grown scatteringly in California, but on account of its poor milling and baking qualities it soon almost disappeared from cultivation.

The soft and hard white common and the white spring club varieties appear to be best adapted to the Sacramento Valley. A number of hard red spring common varieties of southern Asian and European origin also have produced well. The hard red winter wheats are not adapted. They immediately lose their dark-red color and become more or less starchy and spotted with yellow berry. Their yields are comparatively low. Practically the same is true of the durum varieties. Instead of being vitreous the kernels become yellowish and opaque or spotted with starchy areas. The yields of durum wheats were in most cases but little more than half those of Pacific Bluestem. Titanic, or "Seven-headed" wheat, a poulard variety, also was inferior in quality and yield.

Spring varieties, or those with an erect habit of growth, are grown successfully when fall sown in the Sacramento Valley; in fact, the leading commercial varieties are of the so-called spring wheats. They are sown throughout the late fall and winter season. During the winter many spring varieties assume a semispreading habit of growth. Winter varieties, or those with a prostrate habit of growth, may not be sown later than midwinter (about February), as they either fail to develop normally on account of the early dry season or become prostrate and grasslike as the season advances.

NURSERY EXPERIMENTS.

Large numbers of varieties of both domestic and foreign origin have been compared in the nursery. In general, the results agree fairly well with those from the plat experiments. In the miscellaneous group of wheats, which comprises both common and durum varieties, Chul, Propo, Baart, and Pacific Bluestem (White Australian) have been the leading varieties. The Australian group, consisting of Australian varieties, many of them very high yielders, has been described in a previous bulletin.[4] In addition to the three Federation varieties, Canberra has been a high-yielding variety in the nursery and has been advanced to the plat experiments.

The early work in selection of pure lines was done primarily to purify existing varieties, many of which were badly mixed. In 1917 numerous pure lines of Pacific Bluestem were selected from commercial fields in the Sacramento Valley and the adjoining coastal districts. Apparently these have yielded no better than the unselected variety. Several of the highest yielding selections, however, are being continued through the season of 1922.

A few hybrids were grown in 1910 from crosses made in 1906. Over 500 rows of hybrid material, developed cooperatively by Dr. C. E. Leighty, agronomist in charge of eastern wheat investigations, and Dr. H. H. Love, of the department of plant breeding, Cornell University Agricultural Experiment Station, were grown in 1916. This material consisted of intergroup crosses between common, durum, emmer, and spelt wheats. A smaller series has been grown in each succeeding year.

Recently an extensive project in producing hybrids has been inaugurated at Chico. It will be discussed under the heading "Hybridization experiments."

Extensive wheat-classification nurseries have been grown in the seven years from 1915 to 1921, inclusive. Chico has been a good place to grow material for classification studies on account of its favorable climate, where hardy as well as tender material can be grown equally well from fall and winter seeding. Detailed agronomic notes on habits of growth, heading, ripening, disease resistance, etc., have been taken also on this material. Each year a minute study of the botanic characters of the mature plants has been made by specialists. The results are in part the basis for a recent publication.[5]

Leading Varieties of Wheat.

PACIFIC BLUESTEM.

This variety was introduced into California from Australia in the early fifties under the name White Australian. It is identical with a variety known as Pacific Bluestem, which was introduced into Oregon in the eighties. It is a tall, moderately strong-strawed beardless wheat with white chaff and white straw and midsized soft to semihard white kernels which do not shatter easily. It has maintained its importance on account of its yielding capacity coupled with fairly good milling and bread-making qualities. The variety also appears able to withstand excess moisture during the occasional wet winters.

[4] Clark, J. Allen, Stephens, David E., and Florell, Victor H. Australian Wheat Varieties in the Pacific Coast Area. U. S. Dept. Agr., Bul. 877, 25 p., 3 pl. 1920.

[5] Clark, J. Allen, Martin, John H., and Ball, Carleton R. The Classification of American Wheat Varieties. U. S. Dept. Agr., Bul. 1074, 238 p., 76 fig., 60 pl. 1922. Literature cited, p. 219–230.

BAART.

Baart was introduced, under the name Early Baart, from Australia by the United States Department of Agriculture in 1900. It did not become an important commercial variety in California until 1919, when it was widely distributed. Early Baart is a tall slender-strawed bearded wheat with white chaff and straw and large semihard kernels. It is more susceptible to shattering than Pacific Bluestem. In common with other varieties it does not shatter so readily when winter or spring sown as when fall sown. At Chico Baart begins heading from 14 to 20 days earlier than Pacific Bluestem, depending on the date of seeding, and ripens from 4 to 8 days earlier. The difference in time of maturity decreases with the later sowings. The widespread distribution of this variety is due to its improved quality, its producing capacity, and its earliness, which makes it adapted to the drier lands.

FIG. 3.—An increase field of Hard Federation wheat, C. I. No. 4733, showing erect, strong stems 45 inches tall, at Chico, Calif., in 1920.

THE FEDERATION VARIETIES.

The Federation, Hard Federation, and White Federation varieties originated in Australia and are of common ancestry. They are distinct varieties but have a number of characteristics in common.

Hard Federation.—Hard Federation (Fig. 3) is an early short and strong-strawed beardless wheat with brown glumes and white straw, small white kernels, and good nonshattering qualities. It matures from two to four days earlier than Baart. It is a hard wheat with short plump kernels, strongly resembling Marquis in shape. The kernels are uniformly vitreous in texture and usually very free from the whitish starchy spots which are equivalent to yellow berry in the hard red wheats. The variety also shows a curious twisting and curl-

ing of the upper leaves, particularly as it approaches maturity. Hard Federation is susceptible to the usual cereal diseases. It appears to have a slightly higher susceptibility to bunt than the average variety. It also does not appear to produce as well as some varieties after a wet winter. Hard Federation was distributed for commercial growing in 1920 on account of its quality and yield. It is a good milling variety, superior to Baart in most milling and bread-making factors.

White Federation.—White Federation is very similar to Hard Federation. It is an early short and strong-strawed beardless variety with small white kernels which do not shatter readily. Like the Hard Federation it has white straw, but it also has white glumes, which serve to distinguish the two varieties. The kernels are hard and vitreous in texture, but starchy spots are more common, and the color of the kernel is a shade lighter. The shape of the kernel is practically identical with that of Hard Federation. The variety matures about two days later than Hard Federation. It also shows the peculiar curling of the upper leaves. White Federation, like Hard Federation, appears to possess low resistance to excess moisture. Although not quite as good a milling variety as Hard Federation, the White Federation was distributed at the same time on account of its slightly greater yielding capacity.

Federation.—Federation is practically identical with Hard Federation in general appearance except that it has a trifle longer and more uniform spike, and its glumes are a little darker brown in color. It begins heading from six to eight days later and matures from three to five days later than Hard Federation. It has a small soft white kernel with rounded cheeks. The yields of Federation at Chico look promising, and in experiments in adjoining States very good results have been obtained. In quality it is equal to Pacific Bluestem and may prove more productive.

BUNYIP.

Bunyip is an early Australian variety with small white semihard kernels of high quality and is similar in many respects to Hard Federation. It is short, moderately strong-strawed and beardless, with white chaff and straw. It matures from two to four days earlier than Hard Federation. Bunyip was distributed in 1920 by a local agency and is grown on a limited acreage in the Sacramento Valley. It has been grown in both nursery and plat experiments at Chico, but has not shown outstanding yielding capacity.

SONORA.

Sonora is an early short-strawed beardless variety with white straw, brown hairy glumes, and small soft white kernels. It is an important commercial variety in the southern San Joaquin Valley, but produces yields significantly lower than those of Pacific Bluestem. It is not grown commercially in the Sacramento Valley.

LITTLE CLUB.

The club wheats have a place in the wheat culture of this section. Although low in milling value they yield well and are resistant to shattering. The nonshattering quality is especially desirable on

account of the use of the combined harvester in harvesting, which necessitates leaving the grain standing in the field until fully mature. A considerable acreage is sown to club varieties. They are grown mostly on the low fertile soils, where there usually is considerable lodging of the common varieties. Little Club is the most important variety. It is midlate, beardless, with white glumes and straw and soft white kernels.

Milling and Baking Experiments.

In order to determine the milling value of new varieties, milling and baking experiments have been conducted in conjunction with the varietal experiments. This work was begun in 1917, when milling and baking tests were made with 12 varieties, which included the best California wheats as well as the leading winter and spring varieties of the Central and Northern States, for comparison. During subsequent years varieties were added and dropped for various reasons. In the five years the milling and baking quality of 33 different varieties and strains has been tested. During the first three years these experiments were conducted at Fargo, N. Dak., in cooperation with the North Dakota Agricultural Experiment Station and the Bureau of Markets of the United States Department of Agriculture. For the past two years the experiments have been conducted in the milling and baking laboratory of the Bureau of Agricultural Economics (formerly Bureau of Markets) at Washington, D. C., in cooperation with the Grain Division of that bureau.

The annual yields and data on the most important milling and baking factors are shown in Table 9 for each of the five years from 1917 to 1921, inclusive. A five-year summary of data on five varieties and a three-year summary of data on six varieties are presented.

In considering the leading varieties the outstanding features are the consistently high percentages of crude protein, shorts, and water absorption of Hard Federation with generally high percentages of flour and good color and volume of loaf. Early Baart is consistently high in loaf volume and in crude protein and yields a good percentage of flour. In 1921, the only year the data are comparable, Bunyip showed itself to be a milling and baking variety of exceptional good quality.

In the summary of Table 9, which gives the five-year average, Baart is shown as the best milling and bread-making wheat of the three important commercial varieties and is particularly superior in loaf volume. Pacific Bluestem is a fairly good milling and baking variety, although it is low in crude protein, water absorption, and volume. Little Club is of inferior milling value.

Table 9 also gives three-year average data for six varieties, which include Baart, Pacific Bluestem, the three Federation varieties, and Sonora. Hard Federation is superior to Baart in all of the important milling and bread-making qualities except loaf volume, in which Baart excels. White Federation shows a slightly higher percentage of flour and loaf volume than Hard Federation. Federation yielded the largest quantity of flour and shows a loaf volume almost equal to Hard Federation. Sonora shows itself to be about equal in milling value to Little Club.

TABLE 9.— *Yields and results of milling and baking tests of wheat varieties grown at the Plant Introduction Station, Chico, Calif., in the five-year period from 1917 to 1921, inclusive.*

[Data obtained in cooperation with the Bureau of Agricultural Economics (formerly Bureau of Markets), United States Department of Agriculture. Crude protein (column 6) equals nitrogen × 5.7 computed to a basis of 13.5 per cent moisture in the wheat. Abbreviations in column 4: C=common, Cl=club, D=dark, Du=durum, H=hard, N=northern, R=red, S=soft, Samp=sample, Sp=spring, Wa=walla, Wh=white, Wn=winter, Y=yellow. Those samples marked with a star (*) were smutty.]

Season and variety	C. I. No.	Yield per acre.	Grade.	Bushel weight.	Crude protein.	Milling tests.			Baking tests.				
						Flour.	Shorts.	Bran.	Water absorption.	Loaf.			
										Volume.	Weight.	Texture.	Color.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
SEASON OF 1917.													
COMMON WHEATS.													
Soft white spring:		*Bu.*		*Lbs.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*C.c.*	*Gms.*	*P. ct.*	*P. ct.*
Dicklow	3663	46.7		58.0	8.9	71.9	12.4	15.1	55.0	1,710	472	90	96
Galgalos	2398	39.4		61.5	11.2	74.4	15.7	10.1	58.8	2,000	499	95	98
Pacific Bluestem	4067	45.0		61.0	10.7	72.1	15.5	11.3	55.0	1,810	482	92	96
Semihard white spring:													
Baart	1697	47.8		63.0	11.8	72.7	14.6	11.9	55.5	2,290	469	95	97
Hard white spring:													
Talimka	2495	40.5		62.0	11.6	74.7	12.9	13.8	60.3	2,000	494	95	99
Hard red spring:													
Chul	2227	36.6		61.0	10.3	69.9	18.7	13.3	63.0	2,050	498	92	99
Koola	2203–2	39.9		63.0	10.9	73.3	15.7	12.7	59.4	2,200	495	96	100
Marquis	4158	36.0		62.0	11.2	73.5	17.0	10.1	58.8	2,260	480	96	98
Hard red winter:													
Kharkof	1442	37.1		61.0	10.7	76.8	14.8	10.3	60.3	1,880	483	92	94
CLUB WHEATS.													
White winter:													
Hybrid 128	4326	47.8		58.0	8.0	71.8	15.1	11.1	55.3	1,520	477	88	92
White spring:													
Little Club	4066	50.1		59.0	10.4	72.9	13.0	13.0	55.0	1,700	471	86	85
DURUM WHEAT.													
Kubanka	1440	34.7		62.0	11.5	74.3	14.1	11.5	60.0	1,630	478	88	99
SEASON OF 1918.													
COMMON WHEATS.													
Soft white spring:													
Dicklow	3663	30.7	Samp H Wh	57.6	8.4	72.4	10.5	18.1	52.9	1,900	473	89	84
Galgalos	2398	25.1	*1 S Wh	61.9	9.1	72.9	13.3	15.2	58.2	1,720	498	90	94
Pacific Bluestem	4067	21.1	*1 H Wh	60.9	10.3	70.3	9.5	20.1	55.0	1,800	482	88.5	93
Sonora	3622	18.7	*1 Wh Cl	63.0	10.3	73.0	16.5	10.6	57.6	1,850	479	86	85.5
White Australian	3019	22.6	*2 H Wh	59.7	12.8	75.4	12.7	11.1	57.9	2,100	480	87.5	85.5
Semihard white spring:													
Baart	1697	19.7	*3 H Wh	56.9	11.2	67.9	12.8	13.5	57.4	1,710	497	87.5	89
Hard white spring:													
Hard Federation	4980	45.1	*2 H Wh	58.4	11.6	74.4	13.5	10.6	60.9	1,960	497	92	91.5
Talimka	2495	28.4	1 H Wh	61.8	10.7	74.3	14.7	11.7	57.6	1,535	488	79	93.5
White Federation	4981	50.0	*2 H Wh	58.7	10.9	73.1	13.9	10.4	60.0	1,610	497	82	88.5
Hard red spring:													
Chul	2227–2	20.6	*2 R Wa	59.0	12.9	70.7	20.0	12.0	63.8	1,780	509	89	80
Koola	2203–2	30.6	*2 R Wa	61.3	13.6	69.2	14.1	17.7	58.5	1,970	502	92	94
Marquis	4158	30.5	1 N Sp	62.0	10.3	76.4	12.6	11.2	59.1	2,000	481	92	94
Hard red winter:													
Kharkof	1442	25.0	2 D H Wn	59.4	14.1	69.8	17.0	11.4	67.7	1,860	514	87.5	88
CLUB WHEATS.													
White winter:													
Hybrid 128	4326	30.3	*2 Wh Cl	58.1	8.3	72.1	11.8	16.9	52.9	1,770	488	89.5	92.5
White spring:													
Little Club	4066	32.8	2 Wh Cl	58.9	8.9	72.7	11.5	16.1	55.3	1,880	480	83	86
Red spring:													
Hybrid 123	4511		*1 R Wa	59.4	10.1	70.5	14.8	15.2	55.3	1,800	489	89	81

TABLE 9.— *Yields and results of milling and baking tests of wheat varieties grown at the Plant Introduction Station, Chico, Calif., in the five-year period from 1917 to 1921, inclusive*—Continued.

Season and variety	C. I. No.	Yield per acre.	Grade.	Bushel weight.	Crude protein.	Milling tests.			Baking results.				
						Flour.	Shorts.	Bran.	Water absorption.	Loaf.			
										Volume.	Weight.	Texture.	Color.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
SEASON OF 1918—Continued.													
DURUM WHEAT.													
Kubanka	1440	*Bu.* 24.5	*Samp Du	*Lbs.* 57.3	*P.ct.* 15.5	*P.ct.* 71.9	*P.ct.* 19.6	*P.ct.* 9.8	*P.ct.* 63.8	*C.c.* 1,950	*Gms.* 514	*P.ct.* 93	*P.ct.* 88.5
SEASON OF 1919.													
COMMON WHEATS.													
Soft white spring:													
Dicklow	3663	31.3	3 S Wh	56.9	6.8	69.3	9.3	20.4	52.9	1,660	484	86.5	94.0
Federation	4734	38.8	2 H Wh	59.4	7.7	73.1	14.4	12.8	53.8	1,960	487	91.0	93.0
Galgalos	2398	22.1	1 H Wh	60.8	8.8	70.7	11.0	19.2	54.4	1,780	491	94.0	94.0
Pacific Blue-stem.	4067	35.2	2 S Wh	59.8	7.4	69.2	11.2	18.6	52.9	1,600	478	92.0	95.0
Propo	1970	35.0	1 S Wh	60.2	6.8	71.5	11.1	16.9	55.3	1,590	485	92.0	95.5
Sonora	3622	24.2	1 Wh Cl	63.6	6.5	68.2	15.9	17.1	52.9	1,710	484	88.5	92.0
White Australian.	3019	32.1	2 S Wh	59.5	7.4	73.4	14.0	12.5	52.9	1,920	483	92.5	95.0
Semihard white spring:													
Baart	1697	22.9	1 H Wh	62.2	8.2	74.1	10.9	17.1	54.2	1,977	488	91.7	93.7
Hard white spring:													
Hard Federation.	4980	34.4	1 H Wh	62.2	8.9	72.6	17.2	11.9	58.5	1,930	502	94.0	97.0
Talimka	2495	29.6		60.2	7.0	70.3	12.4	18.3	57.4	1,690	500	91.0	90.0
White Federation.	4981	36.7	1 H Wh	61.0	7.7	73.2	16.0	10.7	58.5	1,920	508	93.5	95.0
Hard red spring:													
Chul	2227	34.6		59.5	8.0	73.3	14.3	14.0	55.6	1,500	496	92.0	89.5
Koola	2203–2	31.5		61.1	8.1	72.8	10.3	17.4	55.3	1,920	489	93.0	96.5
Marquis	4158	31.0	1 R Sp	60.1	7.5	71.8	11.5	19.4	55.9	1,720	487	86.0	89.5
Hard red winter:													
Kharkof	1442	25.4	2 Y H Wn	59.7	7.7	71.6	13.9	15.2	56.5	1,940	495	89.5	93.5
CLUB WHEATS.													
White winter:													
Hybrid 128	4326	32.7	3 Wh Cl	57.1	7.3	71.5	9.0	20.5	52.9	1,590	483	88.5	87.0
White spring:													
Little Club	4066	27.5	3 Wh Cl	57.5	7.3	70.0	9.0	20.3	52.9	1,850	480	89.5	89.0
Red spring:													
Hybrid 123	4325	34.6	1 R Wa	59.0	7.0	71.6	12.1	16.7	54.7	1,720	491	90.0	89.0
DURUM WHEAT.													
Kubanka	1440	27.9		60.5	7.9	75.2	12.2	15.3	54.7	1,570	498	92.0	90.0
POULARD WHEAT.													
Titanic	5535	19.8		55.8	8.0	73.9	11.8	14.5	55.6	1,190	487	70.0	85.0
SEASON OF 1920.													
COMMON WHEATS.													
Soft white spring:													
California Gem	2986		2 Wh Cl	58.0	7.9	65.5	9.4	22.9	52.9	1,890	491	88.5	68.0
Federation	4734	51.2	1 S Wh	60.0	9.2	76.5	10.9	13.5	55.9	1,980	493	86.5	90.0
Oudebaard	6228	44.6	Mixed	61.7	8.1	72.8	12.1	16.7	55.6	1,910	497	87.5	92.0
Pacific Blue-stem.	4067	45.0	1 S Wh	60.1	9.2	70.3	14.9	15.2	57.1	1,870	499	91.0	92.0
Propo	1970	35.0	1 S Wh	60.6	8.1	72.4	11.3	16.7	56.5	1,920	494	90.5	97.0
Sonora	3622		1 Wh Cl	62.4	7.6	66.2	11.6	21.7	58.5	1,820	503	89.5	82.0

TABLE 9.—*Yields and results of milling and baking tests of wheat varieties grown at the Plant Introduction Station, Chico, Calif., in the five-year period from 1917 to 1921, inclusive*—Continued.

Season and variety	C. I. No.	Yield per acre.	Grade.	Milling tests.					Baking results.				
				Bushel weight.	Crude protein.	Flour.	Shorts.	Bran.	Water absorption.	Loaf.			
										Volume.	Weight.	Texture.	Color.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
SEASON OF 1920—Continued.													
COMMON WHEATS—continued.													
Semihard white spring:		*Bu.*		*Lbs.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*C. c.*	*Gms.*	*P. ct.*	*P. ct.*
Baart	1697	39.6	C Wh and H Wh.	61.5	10.0	71.3	13.3	16.1	58.8	2,040	510	89.5	95.0
Hard white spring:													
Hard Federation.	4733	40.9	1 H Wh	61.8	10.6	73.0	15.5	12.1	65.9	1,900	519	87.5	94.5
Do	4980	42.9	1 H Wh	61.7	9.9	75.5	15.3	10.6	63.5	1,990	513	86.5	95.0
White Federation.	4981	44.6	1 S Wh	61.3	9.3	75.5	14.2	11.5	61.2	2,010	514	88.5	95.0
Hard red spring:													
Marquis	4158	30.0	1 R Sp	60.9	7.9	73.3	12.3	16.1	56.2	1,800	500	88.0	92.0
Hard red winter:													
Eureka	5170	.....	.....	64.0	11.7	78.3	13.4	13.2	65.6	1,890	516	88.0	89.0
Kharkof	1442	.....	1 H Wn	62.1	8.9	75.4	11.1	15.9	59.1	1,920	507	88.5	91.5
CLUB WHEAT.													
White spring:													
Little Club	4066	35.9	2 Wh Cl	58.4	7.7	73.1	9.9	17.3	52.9	1,820	488	88.5	87.0
SEASON OF 1921.													
COMMON WHEATS.													
Soft white spring:													
Canberra	4986	.....	1 S Wh	63.2	7.7	72.8	11.4	17.7	55.3	1,820	488	84.0	88.0
Federation	4734	17.3	2 S Wh	59.7	7.5	73.8	10.9	18.1	52.9	1,780	483	87.5	92.0
Jumbuck	4608	.....	1 S Wh	63.0	8.5	75.5	17.5	9.4	56.8	1,550	500	90.5	91.0
Oudebaard	6228	19.6	1 Mixed	63.4	7.7	70.3	11.4	21.4	52.9	1,920	480	92.5	92.5
Pacific Bluestem.	4067	16.7	1 S Wh	62.3	8.8	74.1	12.2	14.6	54.4	1,890	484	90.5	90.5
Sonora	3622	19.0	*1 Wh Cl	63.9	7.3	71.9	14.5	16.1	55.6	1,680	493	92.5	84.0
White Australian.	3019	18.0	1 S Wh	62.2	7.8	72.1	12.1	17.5	54.1	1,720	484	93.0	91.5
Semihard white spring:													
Bunyip	5125	13.3	1 S Wh	62.4	8.8	71.5	16.1	15.6	57.1	2,060	495	86.0	93.0
Comeback	4991	.....	1 S Wh	63.5	8.8	70.2	12.6	20.1	55.6	1,920	496	87.5	93.5
Baart	1697	17.4	1 H Wh	64.2	8.7	70.0	12.6	20.4	52.9	2,010	483	90.5	91.5
Onas	6221	.....	1 S Wh	62.0	7.3	66.8	14.3	20.7	52.9	1,880	484	92.5	93.0
Hard white spring:													
Bobs	4710	.....	1 S Wh	63.7	9.5	74.6	16.2	10.9	60.9	2,000	506	93.0	92.0
Hard Federation.	4733	13.8	*1 S Wh	62.0	9.0	71.1	17.4	15.3	58.8	1,880	501	91.5	92.5
White Federation.	4981	12.2	1 S Wh	61.8	7.7	71.3	17.3	13.9	59.1	1,930	497	87.5	92.8
Hard red spring:													
Marquis	4158	16.4	1 R Sp	61.4	7.9	72.3	16.7	13.7	56.8	1,790	499	89.0	91.5
Hard red winter:													
Kharkof	1442	12.5	1 Y H Wn	62.2	7.9	73.2	12.6	17.5	56.2	1,790	491	93.0	93.0
CLUB WHEAT.													
White spring:													
Little Club	4066	16.1	2 Wh Cl	59.3	6.9	74.1	11.0	16.8	51.5	1,830	481	89.5	87.0

TABLE 9.—*Yields and results of milling and baking tests of wheat varieties grown at the Plant Introduction Station, Chico, Calif., in the five-year period from 1917 to 1921, inclusive*—Continued.

SUMMARY OF AVERAGES OF FIVE VARIETIES FOR THE FIVE-YEAR PERIOD.

Season and variety	C. I. No.	Yield per acre.	Grade.	Milling tests.						Baking tests.				
				Bushel weight.	Crude protein.	Flour.	Shorts.	Bran.	Water absorption.	Loaf.				
										Volume.	Weight.	Texture.	Color.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
COMMON WHEATS.														
Soft white:		*Bu.*		*Lbs.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*C.c.*	*Gms.*	*P.ct.*	*P.ct.*
Pacific Blue-stem.	4067	32.6		60.8	.93	71.2	12.7	16.0	54.5	1,794	485	90.8	93.3
Semihard white:														
Baart	1697	29.5		61.7	10.0	71.2	12.8	15.8	55.8	2,005	489	90.8	93.2
Hard red:														
Marquis	4158	28.8		61.3	9.0	73.5	14.0	14.1	57.4	1,874	489	90.2	93.0
Hard red winter:														
Kharkof	1442	[1]25.0		60.9	9.9	73.4	13.9	14.1	60.0	1,878	498	90.1	92.0
CLUB WHEAT.														
White:														
Little Club	4066	32.5		58.6	8.2	72.6	10.9	16.7	53.5	1,816	480	87.3	86.8

SUMMARY OF AVERAGES OF SIX VARIETIES FOR THE YEARS 1919, 1920, AND 1921.

COMMON WHEATS.													
Soft white spring:													
Federation	4734	35.8		59.7	8.1	74.5	12.1	14.8	54.2	1,907	488	88.3	91.7
Pacific Blue-stem.	4067	32.3		60.7	8.5	71.2	12.8	16.1	54.8	1,788	487	91.2	92.5
Sonora	3622	.....		63.3	7.1	68.8	14.0	18.3	55.7	1,737	493	90.2	86.0
Semihard white spring:													
Baart	1697	26.6		62.8	9.0	71.8	12.3	17.9	55.3	2,009	494	90.6	93.4
Hard white spring:													
Hard Federation.	[2]4980	30.0		62.0	9.4	72.0	16.7	12.9	60.7	1,918	506	90.8	94.8
White Federation.	4981	31.2		61.4	8.2	73.3	15.8	12.0	59.6	1,953	506	89.8	94.3

[1] Average for four years. [2] Average of C. I. Nos. 4733 and 4980 used in 1920, and C. I. No. 4733 in 1921.

Hybridization Experiments.

A comprehensive wheat-breeding project, designed to improve the leading varieties of the principal wheat-producing sections of the western half of the United States, was begun at Chico in 1919 under the direction of J. Allen Clark, agronomist in charge of western wheat investigations, and has been continued during 1920 and 1921. Crosses designed primarily to improve California wheats also were included in the crossing program.

In 1918 hybrid wheat material originated at the Sherman County Branch Station, Moro, Oreg., in 1916 and 1917, was grown at Chico, and in 1919 material originated at the Cheyenne Experiment Farm, at Archer, Wyo., was added. The principal object of the crosses made at Moro was to produce a high-yielding awnless hard red winter wheat, and of those made at Archer, Wyo., to improve the quality of Erivan, the highest yielding spring variety at that station.

Previous to this time the work in wheat improvement at Chico had been confined to a limited amount of selection to obtain pure lines. Most of the crosses made at Chico to develop improved varieties for the great sections which produce winter or spring wheat are now being grown at various experiment stations throughout those areas.

The objects for which the crosses at Chico have been made are winter hardiness, rust resistance, smut resistance, earliness, and quality as well as a number of such factors as stiffness of straw and nonshattering habit. The leading parent varieties used are as follows: For winter hardiness, Buffum No. 17, Minhardi, and Minturki; for rust resistance, Kota and Kanred; for smut resistance, Hussar and Martin; for earliness, Sunset and Hard Federation; and for high milling quality, Marquis and Hard Federation. A total of 34 different varieties was used in the 66 combinations made.

A total of 8,889 apparently crossed kernels have been harvested. Less than 1 per cent of the kernels have been found not to be crosses. Approximately 2,950 florets were emasculated in 1919, 3,000 in 1920, and 9,816 in 1921, with 1,210, 1,293, and 6,386 kernels, respectively, harvested in the successive years. The percentages of successful crosses closely approximate 45, 42.1, and 65.1, respectively, in the three years. In 1920 the percentage was lowered by a number of sterile spikelets which had been pollinized in experiments with stored pollen.

BARLEY EXPERIMENTS.

Barley is the most important grain crop of the Sacramento Valley. Approximately three times as much barley as wheat is produced annually. It matures more quickly and yields greater returns than wheat on a large class of soils. It is the principal grain feed of the section for horses and mules and is used also to some extent as a hay crop.

Barley is well adapted to the climate. Its growth and development occur during the latter part of the cool wet season, and it usually reaches maturity before the heat of summer arrives. The crop is sown in late fall, winter, or early spring. Spring varieties sown in the fall survive the winter equally as well as winter varieties.

With the exception of Rhynchosporium, or "leaf scald," barley in the Sacramento Valley is unusually free from plant diseases. Most varieties are susceptible to the disease. Susceptible plants are infected in the early as well as in the later stages of growth.

Varietal Comparisons.

PLAT EXPERIMENTS.

Ninety-two varieties of barley have been grown in the plat experiments in one or more years during the 12-year period from 1910 to 1921, inclusive. These have included the principal varieties from other barley-producing sections in the United States and also many varieties from other countries. The annual yields of 30 of these varieties in some or all of the 12 years, with average yields expressed in percentages of the yield of Coast barley (C. I. No. 690) in the same years, are given in Table 10. The remaining varieties are listed by name and number in Table 11.

Coast and Beldi were the only varieties grown in all of the 12 years. The average acre yield of Coast was 48 bushels and of Beldi 44.9 bushels. Coast, together with several varieties of the Coast type,

has been the highest yielder. The percentage average yield of Peru (C. I. No. 653), a variety almost identical with Coast, was 100.2, while that of Trebi, also a six-rowed variety, was 102.2.

The percentage yield of Maryland Winter in the three years from 1911 to 1913 was 138.2, and that of Wisconsin Winter in the two years 1911 and 1912, was 107.8. The high yields of the former in 1911 and 1912 and of the latter in 1912 are abnormal and are not considered comparable with those of other varieties grown in these years. The highest yielding two-rowed barley was White Smyrna, whose percentage was 92. Club Mariout has produced a yield of 91.8 per cent of that of Coast in a 10-year period. During the past four years it has compared very favorably with Coast.

The six-rowed hulled varieties are best adapted to this section, particularly those of North African origin, which includes the barleys of the Coast type. The two-rowed hulled barleys yield fairly well but none has equaled Coast. The six-rowed naked or hull-less varieties tested have produced about 15 per cent less grain in pounds per acre than Coast. The hooded varieties have been comparatively low in yield.

TABLE 10.— *Yields of 30 varieties of barley grown at the Plant Introduction Station, Chico, Calif., in some or all of the years in the 12-year period from 1910 to 1921, inclusive.*

Group and variety.	C. I. No.	Yield per acre (bushels).												Average.	Percentage of yield o Coast.
		1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921		
6-rowed, hulled, awned:															
Coast	690	13.3	66.3	60.0	47.4	48.0	24.4	64.8	54.1	63.4	36.5	62.5	35.2	48.0	100.0
Beldi	190	13.8	58.4	50.0	41.3	47.0	26.6	49.3	52.0	58.5	47.7	65.7	28.4	44.9	93.5
Telli	194	18.0	60.8	60.0	41.3	40.3	23.0	.....	.....	.....	.....	.....	.....	.....	93.8
Poda	652	.....	43.6	60.0	45.0	31.1	29.3	64.6	55.5	59.2	60.4	52.6	32.8	.....	94.9
Peru	653	.....	68.0	60.0	51.0	.....	25.5	59.0	.....	.....	.....	.....	.....	.....	100.2
Arequipa	1256	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	41.7	.....	118.5
Servian	915	.....	.....	.....	.....	26.5	.....	.....	.....	.....	.....	.....	.....	.....	55.2
Trebi	936	.....	.....	.....	.....	.....	.....	62.5	.....	.....	51.3	58.8	30.8	.....	102.2
Club Mariout	261	13.0	32.4	66.7	37.5	.....	.....	48.2	50.6	61.8	58.6	63.2	30.2	.....	91.8
California Mariout (No. 2241)	1455	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25.8	.....	73.3
Hero (awns smooth)	1286	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23.7	.....	67.3
Oderbrucker	940	.....	.....	.....	.....	36.4	18.0	.....	.....	.....	.....	.....	.....	.....	75.0
Manchuria	643	.....	.....	.....	.....	.....	17.5	.....	.....	.....	.....	.....	.....	.....	71.7
Odessa	916	.....	.....	.....	.....	32.3	23.3	43.5	57.0	48.0	40.1	44.5	.....	.....	81.6
Tennessee Winter	257	.....	60.0	.....	.....	.....	.....	.....	38.7	59.1	31.8	48.8	26.3	.....	84.0
Maryland Winter	518	.....	83.2	90.0	66.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	138.2
Wisconsin Winter	519	.....	52.8	83.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	107.8
Abyssinian	361	.....	.....	60.0	64.5	63.7	25.0	47.4	25.3	30.0	24.0	.....	.....	.....	85.3
2-rowed, hulled, awned, Orel	351	.....	.....	53.3	45.8	.....	.....	49.7	.....	.....	.....	.....	.....	.....	86.4
6-rowed, hulled, hooded, Meloy	1176	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	45.0	5.5	.....	51.7
6-rowed, naked, hooded, Nepal	2315	.....	.....	.....	.....	35.4	24.0	.....	.....	.....	.....	.....	.....	.....	82.0
6-rowed, naked, awned:															
Black Hull-less	597	.....	.....	53.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	88.8
Himalaya (Zvolanek's 6-row Hull-less)	1312	.....	.....	.....	.....	.....	.....	.....	.....	.....	22.8	61.3	.....	.....	84.9
2-rowed, hulled, awned:															
Hannchen	531	.....	.....	73.3	57.0	.....	27.8	33.7	33.0	35.1	36.2	54.4	.....	.....	84.8
Invincible	590	.....	.....	.....	.....	29.8	18.0	46.7	.....	.....	.....	.....	.....	.....	68.9
Svanhals	187	.....	.....	.....	.....	28.5	14.5	.....	.....	.....	.....	.....	.....	.....	59.4
Heil Hanna, No. 2	678	.....	.....	.....	.....	31.6	19.3	58.3	40.8	44.9	34.9	.....	.....	.....	78.9
Goldfoil	928	.....	.....	.....	.....	34.5	21.0	33.3	.....	.....	.....	.....	.....	.....	66.9
Chevalier	278	.....	44.8	60.0	32.3	.....	.....	57.7	45.7	46.3	28.9	.....	.....	.....	80.4
White Smyrna	195	25.4	59.2	56.7	54.0	43.5	21.5	55.7	46.4	48.6	48.6	49.4	20.8	44.2	92.0

TABLE 11.—*List of varieties of barley grown in plats, but in not enough years or not sufficiently promising to include in Table 10.*

Name.	C. I. No.	Name.	C. I. No.	Name.	C. I. No.
Nepal	22	Chevalier	156	Bavarian	159
Princess	193	Hankau	197	Nerchinsk	216
Nepal	234	Coast	276	Abyssinian	355
Hanna	416	Gatami	575	Golden Grain	588
Nesbian	647	Black Hull-less	618	Virginia Hooded	648
Abyssinian	673	Franconian	679	Heil Hanna, No. 1	681
Coast	691	Hansee Hull-less	703	Popeline	704
Black Russian	705	Black Algerian	708	Turkestan Winter	711
Kopeck	869	Black Hull-less	735	Proskowetz	893
Luth	908	White Smyrna	910	Mahrische	912
Italian	914	Australian White	925	Summit	929
Steigum	931	Odessa	934	Sandrel	937
Abyssinian	938	Palestine	939	Abyssinian	941
Hanna	942	Abyssinian	943	Holland	952
Abyssinian	946	Abyssinian	950	Frankish	953
Featherston	954	Golden Melon	958	Alpha	959
Hanchamont	1121	Abyssinian	1236	Sagina	1269
Blarney	1303	Hurst	1304	Loudon	1308
Coast	2306	Coast	2307	Abina	2308
Hanna	2309	Peru	2311	Coast	2312
Abyssinian	2313	Abyssinian	2314	Hanna	2316

NURSERY EXPERIMENTS.

Numerous barleys from various sources have been tested in the varietal nursery. (Figs. 4 and 5.) The agronomic notes include special notes on Rhynchosporium infection and types of shattering. Coast (C. I. No. 690) has consistently been one of the best varieties. A few promising varieties have been advanced to the plat experiments. Most barley varieties are not adapted to California conditions.

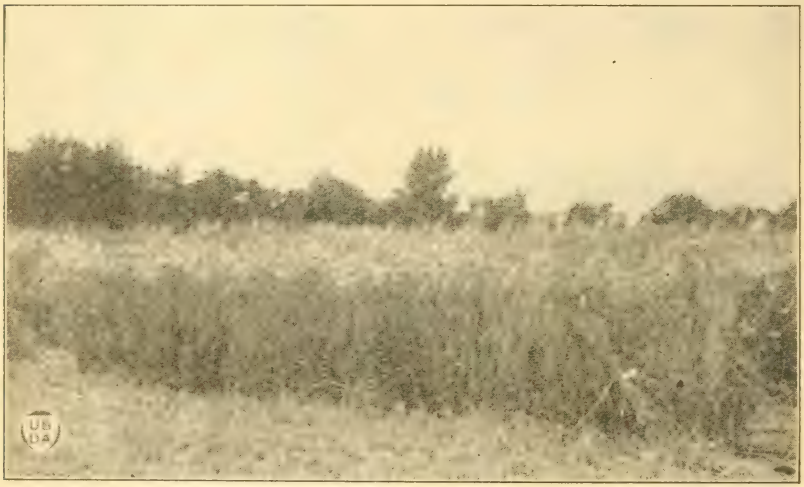

FIG. 4.—Some of the pure-line selections of barley growing in nursery rows at the Plant Introduction Station, Chico, Calif., in 1920.

The early work in pure-line selection was primarily to select for desirable lines from varieties showing variations. From 1915 to 1918 a number of smooth-awned selections were grown. These were originated by Dr. H. V. Harlan, agronomist in charge of barley investigations, for the purpose of developing smooth-awned sorts of particular value as hay barleys. The smooth-awned character appeared

to be well fixed in most selections, but very few are adapted to the Sacramento Valley. They do not yield well and shatter easily. Only one of these selections is of promise. This has Club Mariout as one parent and has been named Hero. It is now being tested in the plat experiments.

In an effort to improve the ordinary Coast variety some 360 selections from commercial fields were made in 1917. Coast as commercially grown is a composite variety whose various forms show considerable variations in yield. The best of these selections are being continued.

A dormancy experiment with barleys was conducted in 1920 and 1921. Eleven varieties of barley were sown at intervals of two weeks from autumn until late spring to determine after what date of sowing in spring a winter variety could not develop normally and produce heads in the same season. Notes on the first heading of all sowings

FIG. 5.—Harvesting the extensive barley nursery at the Plant Introduction Station, Chico, Calif., in 1920.

were made to secure additional information on dormancy. These preliminary experiments show that winter varieties can not be safely sown after midwinter.

Leading Varieties.

COAST.

Coast is the most important barley in the Sacramento Valley as well as in the entire Pacific coast area. It is a midseason, six-rowed, hulled variety with midtall strong straw and long stiff awns. It stands well after maturity and does not shatter easily. Its awns are strongly barbed, which is objectionable when the barley is cut for hay. Although the kernels are large, the awns tend to remain attached to the threshed grain, which often results in low bushel weights. Coast is best adapted to well-drained soils, where it grows vigorously and produces large yields under favorable conditions.

CALIFORNIA MARIOUT.

California Mariout was distributed by the California Agricultural Experiment Station in 1919. Since then it has become widely distributed not only throughout the valley but over the entire State. It was not included in the experiments at Chico until 1921, and then the unfavorable season resulted in a low yield.

California Mariout is an early six-rowed hulled, moderately long-awned variety, with medium strong but short straw. Its spikes are moderately long and somewhat resemble those of Coast, but its kernels can be distinguished by the hairy or bristly rachilla, which is smooth in Coast. It is a very early variety, capable of maturing grain when sown much later in the spring than Coast. The straw is extremely short except on the more fertile soils, and this sometimes interferes with harvesting operations. The variety appears to possess drought resistance to a marked degree. It appearently will produce good yields on a wide range of soils but may find its best adaptation on the lighter soils in the interior valleys from Sacramento southward and in situations where an early-maturing variety is desired for late sowing.

CLUB MARIOUT.

Club Mariout (C. I. No. 261) is grown to a limited extent on the west side of the Sacramento River in the vicinity of Willows. It was distributed in 1919 by local agencies that secured their supply of seed from Oregon. This variety, which has been known as Mariout, was distributed and grown commercially in Oregon before the California Mariout was distributed. It also has been grown long at various experiment stations and has been reported upon in a number of bulletins under the name of Mariout.

In California it has been called Oregon Mariout in order to distinguish it from the California Mariout. Realizing that these names would surely result in confusion, the Office of Cereal Investigations has renamed it Club Mariout, to call attention to its short, compact, clublike spike.

Club Mariout is a midseason six-rowed hulled and awned variety with midtall and strong straw. It has a plump, bright kernel of excellent quality which does not shatter readily. It usually is a few inches shorter, matures a few days earlier, and is a little more susceptible to lodging than Coast.

WHITE SMYRNA.

White Smyrna is an early two-rowed hulled and awned variety with short, tender straw, which in some seasons has a tendency to lodge. The kernels, which are among the largest and plumpest found in any variety, are heavy and resist shattering nearly as well as those of Coast. White Smyrna has been fairly good in productivity, but on account of its short straw it probably would not prove satisfactory on the lighter soils.

NEPAL.

Nepal is an early hooded white-kerneled naked variety with midtall straw and broad leaves. It is subject to drought injury and does not yield heavily. It is best adapted to the higher elevations and cooler sections of the West.

OTHER VARIETIES OF BARLEY.

There are three types of barley frequently advertised which either are unsuited to California conditions or are suited only to special locations or specific purposes. These are the Manchuria-Oderbrucker, the Horsford, and the Chevalier. The Manchuria-Oderbrucker is a type of barley which occupies practically the entire barley acreage of the northern Mississippi Valley. It is a six-rowed variety with smaller kernels, finer awns, and more lax spikes than Coast. It is totally unsuited to the interior valleys of California. It does not yield well and shatters badly.

The Horsford type is the six-rowed hulled hooded form sold under many names, such as Beardless and Success. For a hay crop the absence of awns is a great advantage. Most of the Horsford strains, however, have originated from crosses of the Nepal on the Manchuria-Oderbrucker type. The spikes are very brittle and the shattering loss exceedingly large. There are a few varieties resulting from crosses of Nepal on the ordinary Coast barley. Of these the Meloy is the best known. These forms are much less brittle, and if a beardless barley is to be grown effort should be made to secure seed of the latter type.

The Chevalier is a late two-rowed hulled awned variety originally from England. It is not suited to the interior valleys of California. In some of the coastal valleys, such as the Salinas Valley, where a long, cool ripening season exists, the Chevalier can be grown with good success and an exceptional quality of grain obtained.

OAT EXPERIMENTS.

A comparatively small acreage of oats is grown in the Sacramento Valley. Warm temperatures, which often occur in the latter part of the growing season, are not favorable to the proper development of oat plants. They shatter quickly if left standing after maturity and therefore are not well adapted to the method of harvesting commonly used. The wild oat is a bad weed in cultivated fields and is difficult to eradicate.

Varietal Comparisons.

Twenty-four varieties of oats, including leading varieties from other oat-growing sections, have been tested in the plat experiments within the seven-year period from 1910 to 1916, inclusive. The annual acre yields of eight of these varieties, with the seven-year average yields expressed in percentages of that of the Red Rustproof (California Red) grown in the same years, are given in Table 12. The average acre yield of Sixty-Day in the seven years was 39.1 bushels and that of Red Rustproof 38.3 bushels. Winter Turf (Dewey) yielded practically the same as Red Rustproof. In the nursery varietal experiments the Fulghum oat has been one of the best varieties during the past three years. The average acre yield of four strains of Fulghum in the two years 1919 and 1920 was 26.4 bushels and that of four strains of Red Rustproof in the same period 22.6 bushels.

Early-maturing varieties of oats are best adapted to the Sacramento Valley. They may be grown successfully if sown on clean land in the fall and harvested before shattering occurs. Midseason and late varieties do not mature properly.

The names and Cereal Investigations numbers of other varieties grown in the varietal plats but not included in Table 12 are given in Table 13.

TABLE 12.—*Yields of eight varieties of oats grown at the Plant Introduction Station, Chico, Calif., for three or more years in the seven-year period from 1910 to 1916, inclusive.*

Group and variety.	C. I. No.	Yield per acre (bushels).								Percentage yeald of Red Rustproof.
		1910	1911	1912	1913	1914	1915	1916	Average.	
Early yellow:										
Sixty-Day	165	31.0	52.3	60.0	[1] 43.8	[2] 39.2	[3] 20.9	26.3	39.1	102.1
Early red:										
Burt	293	21.5	57.5	35.0	.....	.....	.....	.....	.....	89.5
Red Rustproof (California Red)	616	24.3	[4] 65.6	[3 4] 37.5	[4] 41.8	[5] 43.3	27.3	28.5	38.3	100
Algerian	286	16.6	58.7	30.0	.....	.....	.....	.....	.....	82.7
Midseason white:										
Danish Island	519	.....	.....	20.0	35.3	[6] 51.4	24.5	20.4	.....	85
Silvermine	520	.....	.....	25.0	23.0	[7] 38.5	17.0	21.3	.....	70
Ligowo	525	.....	.....	30.0	19.8	[8] 44.8	19.5	24.4	.....	77.6
Winter:										
Winter Turf (Dewey)	180	.....	88.7	30.0	[3] 36.9	[9] 38.7	24.8	23.6	.....	99.5

[1] Average of four check plats.
[2] Average of selections 165–1 and 165–2 substituted.
[3] Average of two check plats.
[4] "Common oats" substituted.
[5] Average of three check plats.
[6] Average of selections 519–1 and 519–2 substituted.
[7] Yield of selection 520–1 substituted.
[8] Yield of selection 525–1 substituted.
[9] Yield of selection 180–1 substituted.

TABLE 13.—*List of varieties of oats grown in plats but not included in Table 12.*

Name.	C. I. No.	Name.	C. I. No.	Name.	C. I. No.
Snoma (Winter Turf)	274	Virginia Gray (Winter Turf)	427	Storm King	522
Culberson	276	Canadian	444	Tartar King	523
English White (Swedish Select)	291	White Tartar	445	Great Northern	524
Appler (Red Rustproof)	339	Black Tartar	446	Gold Finder	526
Italian Rustproof	421	Red Rustproof	451	Abundance	527
		Big Four	521	Colossal	528
				Fulghum	650

A number of the important varieties from the leading oat-producing sections have been grown in the nursery also. Red Rustproof (California Red) and Fulghum, both early-maturing oats, have been among the best varieties.

Leading Varieties.

As a general group the so-called red oats are preferable to all other types for the peculiarly hot, dry climatic conditions of the Sacramento Valley. Red Rustproof and Fulghum are distinctly warm-climate varieties and therefore are naturally better adapted than the common varieties of yellow and white oats as represented by Sixty-Day, Swedish Select, Silvermine, etc. Owing to the importance of the red oats as a group in California, descriptions of the Red Rustproof and Fulghum varieties follow.

RED RUSTPROOF.

The Red Rustproof in California has been known under several different names, the most usual of which are Common California Red, California Red, Red Coast, Red Inland, and Red Texas. It is an early midtall variety with fine to midcoarse but rather stiff straw.

The panicles are not large, but they produce large plump kernels, yellowish red to light brown in color. The kernels are awned and bear basal bristles. While the variety possesses considerable rust resistance, this character is not important in the interior valleys where rust infection usually is very light.

FULGHUM.

Fulghum is a comparatively new variety which appears to be well adapted to parts of the winter-oat belt of the Southern States and the southern and southwestern portions of the spring-oat sections. In Kansas a strain called Kanota appears to be of unusual promise. In the Sacramento Valley of California Fulghum matures from six to eight days earlier than Red Rustproof and in view of its high yielding capacity should prove valuable there, where earliness is a particularly important factor.

Fulghum is slightly taller than Red Rustproof and has stiff and moderately coarse culms tinged with red and bearing numerous wide leaves. The panicles are midsized with rather short branches, which makes them appear very erect. The kernels are somewhat smaller than those of Red Rustproof and usually are free from the awns and basal hairs found in that variety. The color of the kernel of Fulghum is a light yellowish brown.

MISCELLANEOUS EXPERIMENTS AND NOTES.

Under this heading are presented the results of limited experiments and observations on emmer and spelt, flax, grain sorghums, and the best dates for seeding cereals.

Emmer and Spelt.

Emmer and spelt probably will never have much economic importance in the Sacramento Valley. They are not well adapted to the climate, it is often difficult to secure a stand, and their production usually is lighter than that of the more valuable grain crops, such as barley and wheat.

Three lots of emmer and one variety of winter spelt were grown in plats in 1911, 1913, and 1914. Annual and average acre yields in pounds are given in Table 14. These yields are light, as they represent the weight of the kernels wholly or mostly still inclosed in the hulls after threshing. In 1911 the varieties were grown on single 1/40-acre plats, in 1913 on single 1/25-acre plats, and in 1914 on single 1/50-acre plats.

TABLE 14.— *Yields of four varieties of spelt and emmer at the Plant Introduction Station, Chico, Calif., for one or more of the three years 1911, 1913, and 1914.*

Crop and variety.	C. I. No.	Yield per acre (pounds).			
		1911	1913	1914	Average.
Black Winter emmer	2337	3,480	[1] 1,625	[1] 1,070	2,058
Emmer (from Abyssinia)	2510–1	1,960	.....	1,000	1,480
Do	2510–2	2,120	.....	910	1,515
Red Winter spelt	1772	3,520	1,900	.....	2,710

[1] Average of two plats.

Flax.

Representative varieties of flax were sown in single and in replicated rows in some or all of the seven years from 1914 to 1920. In most cases sowings were made in the fall. In one of the seasons the crop winterkilled, and in two others very low yields were produced. Tashkent (C. I. No. 11) and Williston Golden (C. I. No. 25) were the best varieties in a three-year average of yields of 13 varieties. Flax is not well adapted to the Sacramento Valley but produces the best yield as well as quality when sown in the fall.

Grain Sorghums.

Grain sorghums, known locally as "corn," are grown to some extent in the Sacramento Valley. They usually are sown on fallow land in alternation with wheat. The reserve supply of moisture in the fallow is depended upon to produce the crop.

Grain sorghums were grown in a limited way at the Plant Introduction Station in the seven years 1912 and 1914 to 1917, inclusive. A varietal experiment was conducted in 1912, and an environmental experiment to determine the chemical analysis of the kernels in crops grown from seed raised in different sections of the country was conducted during the longer period. Dwarf milo appears to be the variety best adapted to the section.

Date-of-Seeding Experiments.

Pacific Bluestem and Baart wheat, Coast and California Mariout barley, Fulghum and Winter Turf oats, and North Dakota No. 1215 flax were grown in replicated rows in a nursery date-of-seeding experiment during 1920 and 1921. Sowings were begun in October and continued at intervals of two weeks for 13 and 14 dates, respectively. The results in these two years agree closely with those reported by successful commercial growers. The largest yields were produced from the early sowings in all cases. Observations on the results of growers as well as on the date-of-seeding experiments indicate that wheat generally may be sown as late as the middle of January with fairly good results. Barley may be sown somewhat later, but oats and flax should be sown before the end of December.

SUMMARY.

Cereal experiments have been conducted at the Plant Introduction Station, Chico, Calif., in the 12 years 1910 to 1921, inclusive.

The principal lines of investigation have been varietal experiments with wheat, barley, and oats and breeding and classification studies with wheat. The most important cereals in the Sacramento Valley are barley and wheat.

The Plant Introduction Station is located 4 miles southeast of Chico near the foothills of the Sierra Nevada Mountains at an altitude of 189 feet. The soil is a loam to sandy loam and is fairly representative of the more fertile soils of the valley.

The average annual precipitation at Chico in the past 51 years was 23.69 inches. The average seasonal precipitation (September to May, inclusive) in the same period was 23.24 inches. The summer months are practically rainless.

On the average, high yields of wheat and barley, moderate yields of oats, and low yields of flax, emmer, and spelt were produced.

The best average yields of wheat were obtained from Pacific Bluestem (White Australian) and Baart. Hard Federation, White Federation, and Federation are new promising varieties. The white common wheats are best adapted to the Sacramento Valley. Durum wheats are not adapted.

Milling and baking data on 33 varieties of wheat show that Hard Federation is superior in most milling and baking factors. Baart excels in loaf volume. White Federation has a milling and baking value almost equal to that of Hard Federation. Bunyip has excellent milling and bread-making qualities. Pacific Bluestem is a fairly good bread-making wheat, with Federation slightly superior. Sonora and Little Club are of inferior value.

Extensive wheat-breeding experiments have been conducted to produce new productive adapted varieties, resistant to disease and with other desirable characters.

Varieties of the Coast type of barley are best adapted to this section. Coast (C. I. No. 690) has been one of the best varieties. Club Mariout (C. I. No. 261) has been a high-yielding variety.

Oats are not well adapted to the Sacramento Valley. Red Rustproof and Fulghum are two of the best varieties.

Emmer and spelt have not yielded as well as wheat or barley. Flax is not adapted to the Sacramento Valley. Grain sorghums may be grown successfully. Dwarf milo is one of the best varieties.

The largest yields of wheat, barley, oats, and flax usually are obtained when sowing is done before December 31.

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